

PATENT COOPERATION TREATY

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INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

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Applicant's or agent's file reference 6550-077/POA	FOR FURTHER ACTION		See Form PCT/PEA/416
International application No. PCT/US2004/011702	International filing date (day/month/year) 15.04.2004	Priority date (day/month/year) 15.04.2003	
International Patent Classification (IPC) or national classification and IPC F03G7/06, C23C14/20, C22F1/00, F16K31/00			
Applicant BOARD OF TRUSTEES OPERATING MICHIGAN STATE UNIVERS			

- This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.
- This REPORT consists of a total of 7 sheets, including this cover sheet.
- This report is also accompanied by ANNEXES, comprising:
 - ☒ sent to the applicant and to the International Bureau a total of 5 sheets, as follows:
 - ☒ sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).
 - ☐ sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.
 - ☐ (sent to the International Bureau only) a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or tables related thereto, in computer readable form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).

- This report contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☐ Box No. VII Certain defects in the international application
- ☐ Box No. VIII Certain observations on the international application

Date of submission of the demand 11.11.2004	Date of completion of this report 11.07.2005
Name and mailing address of the international preliminary examining authority:  European Patent Office - P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk - Pays Bas Tel. +31 70 340 - 2040 Tx: 31 651 epo nl Fax: +31 70 340 - 3016	Authorized Officer O'Shea, G Telephone No. +31 70 340-4424 

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ON PATENTABILITY**

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Box No. I Basis of the report

1. With regard to the **language**, this report is based on the international application in the language in which it was filed, unless otherwise indicated under this item.

☐ This report is based on translations from the original language into the following language , which is the language of a translation furnished for the purposes of:

- ☐ international search (under Rules 12.3 and 23.1(b))
☐ publication of the international application (under Rule 12.4)
☐ international preliminary examination (under Rules 55.2 and/or 55.3)

2. With regard to the **elements*** of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report)*:

Description, Pages

1-19 as originally filed

Claims, Numbers

1-37 received on 17.02.2005 with letter of 15.02.2005

Drawings, Sheets

1-24 as originally filed

☐ a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing

3. ☐ The amendments have resulted in the cancellation of:

- ☐ the description, pages
☐ the claims, Nos.
☐ the drawings, sheets/figs
☐ the sequence listing (*specify*):
☐ any table(s) related to sequence listing (*specify*):

4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).

- ☐ the description, pages
☐ the claims, Nos.
☐ the drawings, sheets/figs
☐ the sequence listing (*specify*):
☐ any table(s) related to sequence listing (*specify*):

* If item 4 applies, some or all of these sheets may be marked "superseded."

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Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes: Claims	1-31,35-37
	No: Claims	
Inventive step (IS)	Yes: Claims	1-16,25-31,35-37
	No: Claims	17-24
Industrial applicability (IA)	Yes: Claims	1-31,35-37
	No: Claims	

2. Citations and explanations (Rule 70.7):

see separate sheet

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Re Item V

**Reasoned statement with regard to novelty, inventive step or industrial applicability;
citations and explanations supporting such statement**

1. Reference is made to the following documents:

- D1: US-A-4 864 824 (GABRIEL KAIGHAM J ET AL) 12 September 1989
- D2: US-A-5 061 914 (BUSCH JOHN D ET AL) 29 October 1991
- D3: US-A-5 825 275 (SU QUANMIN ET AL) 20 October 1998
- D4: WO 96/39547 A (UNIV CALIFORNIA) 12 December 1996
- D5: EP-A-0 161 952 (SOURIAU & CIE) 21 November 1985

2. The present application does not meet the criteria of Article 33(1) PCT, because the subject-matter of claim 17 does not involve an inventive step in the sense of Article 33(3) PCT.

2.1 The document D2 is regarded as being the closest prior art to the subject-matter of claim 17, and discloses (the references in parentheses applying to this document):

A method for producing a plurality of thin film actuators (col.4 lines 49-55) comprising:
a) sputter depositing (col.3, lines 29-36) a film of a shape memory alloy material onto a substrate (10)(see figure 3c) to form a shape memory alloy construction;
b) annealing the shape memory alloy construction (see col. 6, lines 5-15);
c) imparting a 2 to 8% strain (col.6, lines 18-22) to the shape memory alloy construction; and
d) conducting a post straining process (col.6, lines 25-32) on the shape memory alloy construction after the step of imparting a 2 to 8% strain.

The expression "a post straining process" is sufficiently broad as to encompass the etching process described in column 6, lines 25-32. The subject-matter of claim 17 therefore differs from this known method in that the substrate is a polyimide film.

The subject-matter of claim 17 of the present application cannot be considered as involving an inventive step (Article 33(3) PCT) as the use of polyimide or polymers in general as a substrate material in conjunction with the sputter depositing of shape

memory alloy material thereon, is one of the design alternatives at the disposal of the skilled person (see document D3, col.2, lines 62-64 and col.3, lines 15-17) and as such, its use as a substrate material in the method of claim 17 would be obvious. Furthermore, the specific choice of a polyimide substrate is merely one of several straightforward possibilities from which the skilled person would select, in accordance with circumstances, without the exercise of inventive skill, in order to produce thin film actuators.

- 2.2 Dependent claims 18-24 do not contain any features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of inventive step over the disclosure of documents D2 and/or D1, D3-D5. This is because the subject-matter of these claims consists either of well known process steps (such as those involved in training the shape memory alloy or applying a photo resist mask), non-inventive choices of materials or merely constructional details well-known to the skilled person.

It is to note that it is not clear from the formulation of claim 18 whether the step of cutting the shape memory alloy construction occurs before or after the straining step © of claim 17.

- 2.3 The combination of the features of dependent claims 25-28 is neither known from, nor rendered obvious by, the available prior art.

- 3.1 The document D2 is regarded as being the closest prior art to the subject-matter of claim 29, and discloses (the references in parentheses applying to this document) a method for producing a plurality of thin film actuators (col.4, lines 49-55) comprising: sputter depositing (col.3, lines 29-36) a film of shape memory alloy material onto a substrate (10)(see figure 3c) to form a shape memory alloy construction; and imparting a 2-8% strain (col.6, lines 18-22) to the shape memory alloy construction; and etching the shape memory alloy film using a photolithographic method (col.6, lines 25-32).

The subject-matter of claim 29 therefore differs from what is known from document D2 in that the substrate is a polymer film and the shape memory alloy construction is

cut to form a plurality of thin film actuators after the etching step. The expression "comprising" of claim 29 does not preclude the possibility of the cutting step being performed before the straining step. However, for the purposes of assessing the inventive step of the claim, it has been interpreted that the cutting step is indeed performed after the straining step.

The subject-matter of claim 29 is therefore new (Article 33(2) PCT).

The problem to be solved by the present invention may be regarded as how to improve the manufacturing process of SMA thin film actuators.

The solution to this problem proposed in claim 29 of the present application is considered as involving an inventive step (Article 33(3) PCT) for the following reasons:

Cutting the polymer substrate into actuators after the step of subjecting the sheet of actuators to strain, greatly increases the speed of actuator formation and also significantly reduces the manufacturing costs involved. There are no teachings or suggestions in the prior art to perform the cutting step on an already strained sheet of actuators and the skilled person would therefore not be prompted to implement this step in combination with the steps outlined in document D2 to arrive at the method of claim 29.

- 3.2 The same reasoning applies, *mutatis mutandis*, to the subject-matter of corresponding independent method claim 1, which therefore is also considered inventive (Article 33(3) PCT).
- 3.3 Due to the fact that the blister valve of claim 35 has been defined with the aid of process steps (such as "the layer of shape memory alloy being subjected to heavy ion irradiation.....etc") and the lack of clarity arising from the definition of the term "damage" of the crystal lattice, this claim appears to define a method of producing a blister valve rather than a blister valve *per se*. This claim has therefore been interpreted as a *method of producing a blister valve*. With such an interpretation, the subject-matter of claim 35 would seem to satisfy the criteria of Article 33 PCT with

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respect to novelty and inventive step. The same reasoning applies to claim 37.

- 3.4 Claims 2-16, 30, 31 and 36 are dependent on claims 1, 29 and 35 respectively and as such also meet the requirements of the PCT with respect to novelty and inventive step.

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CLAIMS

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What is claimed is:

1. A method for producing a plurality of thin film actuators
5 comprising:
 - a) degassing a polymer film in a vacuum;
 - b) depositing a film of a shape memory alloy material onto the
polymer film;
 - c) imparting a strain to the polymer film by 2 to 8% strain; and
 - 10 d) cutting the polymer film to form a plurality of thin film
actuators after the step of imparting a strain.
2. The method according to Claim 1 wherein the polymer film is a
polyimide film.
3. The method according to Claim 1 wherein depositing a film of
15 shape memory alloy is sputter coating a layer of shape memory alloy onto the
polymer film.
4. The method according to Claim 1 wherein depositing a film of
shape memory alloy is depositing a film of shape memory alloy selected from
the group consisting of TiNiPd, TiNiAu, TiNiZr, TiNiHf, TiNiPt and combinations
20 thereof.
5. The method according to Claim 1 wherein the step of imparting
strain to the polymer film is imparting a uniaxial strain.
6. The method according to Claim 1 wherein the step of imparting a
strain is imparting biaxial strain.
7. The method according to Claim 1 wherein the step of imparting a
25 strain is done in a cyclic manner by heating and cooling under applied uniaxial
or biaxial loading with the last cycle ending with strain applied in the fully
martensitic condition.
8. The method of Claim 1 further comprising the step of exposing
30 the shape memory alloy layer to a photo resist mask prior to cutting the
polymer film into a plurality of actuators.

9. The method according to Claim 8 further comprising etching the shape memory alloy material prior to cutting the polymer film into a plurality of actuators.

10. The method according to Claim 1 further comprising layering
5 portions of the film with a conductor.

11. The method according to Claim 10 wherein the conductor is between 1 and about 100 microns thick.

12. The method according to Claim 10 wherein the conductor is selected from the group consisting of Cu, Au, Ag, Ni, Cr and combinations
10 thereof.

13. The method according to Claim 1 further comprising the step of annealing the shape memory alloy.

14. The method according to Claim 1 further comprising sputter
coating a second layer onto the shape memory alloy layer.

15. The method according to Claim 14 wherein the second sputter
15 coat is a conduction layer.

16. The method according to Claim 14 wherein the second layer is a plating assist layer.

17. A method for producing a plurality of thin film actuators
20 comprising:

a) sputter depositing a film of a shape memory alloy material onto a polyimide film to form a shape memory alloy construction;

b) annealing the shape memory alloy construction;

c) imparting a 2 to 8% strain to the shape memory alloy

25 construction; and

d) conducting a post straining process on the shape memory alloy construction after the step of imparting a 2 to 8% strain.

18. The method according to Claim 17 further comprising the step of cutting the shape memory alloy construction to form a plurality of thin film
30 actuators after the step of conducting a post annealing process.

19. The method according to Claim 17 wherein the step of imparting strain to the polymer film is imparting a uniaxial strain.

20. The method according to Claim 17 wherein the step of imparting a strain is imparting biaxial strain.

21. The method according to Claim 17 wherein depositing a film of shape memory alloy is depositing a film of shape memory alloy selected from the group consisting of TiNiPd, TiNiAu, TiNiZr, TiNiHf, TiNiPt and combinations thereof.

22. The method of Claim 17 further comprising the step of exposing the shape memory alloy layer to a photo resist mask prior to cutting the polymer film into a plurality of actuators.

23. The method according to Claim 17 further comprising etching the shape memory alloy material prior to cutting the polymer film into a plurality of actuators.

24. The method according to Claim 17 wherein the step of imparting strain to the polymer film comprises the steps of:
placing the shape memory alloy construction over a die;
applying differential pressure into the die to deform the shape memory alloy construction.

25. The method according to claim 24 further comprising subjecting the shape memory alloy layer to ion irradiation to a depth of about one-half the thickness of the shape memory alloy layer.

26. The method according to claim 25 wherein subjecting the shape memory alloy layer to heavy ion irradiation is subjecting the shape memory alloy layer with heavy ions such as argon or krypton to damage the crystal structures to a degree that reverse transformation to the austenite is prevented.

27. The method according to claim 25 further comprising cutting the polymer film to form a plurality of thin film actuators after the step of imparting a strain.

28. The method according to claim 27 further comprising coupling two thin film actuators together to form a blister actuator.

29. A method for producing a plurality of thin film actuators comprising:

a) sputter depositing a film of a shape memory alloy material onto a polymer film to form a shape memory alloy construction;

b) imparting a 2 to 8% strain to the shape memory alloy construction;

5 c) etching the shape memory alloy film using a photolithographic method, wherein the polymer film is substantially unaffected by the photolithographic method; and

d) cutting the shape memory alloy construction to form a plurality of thin film actuators after the step of etching the shape memory alloy film.

30. The method according to claim 29 wherein the step of imparting strain to the polymer film is imparting a uniaxial strain.

31. The method according to claim 29 wherein the step of imparting a strain is imparting biaxial strain.

15 32. (Cancelled)

33. (Cancelled)

34. (Cancelled)

35. A blister valve comprising:

20 a first thin film member having a layer of shape memory alloy, the first thin film being plastically deformed to form a blister shape, the layer of shape memory alloy being subjected to heavy ion irradiation at an ion energy chosen to produce crystal lattice damage to a depth of about one-half the thickness of the layer of shape memory alloy; a first vent pore defined in the first film member;

25 a second member disposed generally parallel to the first thin member, said second member defining a second pore, said second pore being misaligned from the first pore; and

wherein first thin film member flattens upon heating and wherein when the first thin film member cooled, an outer elastic layer resets the blister.

30 36. The blister valve according to claim 35 wherein the second member is a second thin film member having a layer of second shape memory alloy, the second thin film being plastically deformed to form a blister shape, the

second layer of shape memory alloy being subjected to heavy ion irradiation at an ion energy chosen to produce crystal lattice damage to a depth of about one-half the thickness of the second layer of shape memory alloy; the second vent pore defined in the second film member.

5 37. An actuator comprising:

 a polymer film;

 a shape memory film deposited on a top surface of a polymeric film, the shape memory film being is subjected to heavy ion irradiation at an ion energy chosen to produce crystal lattice damage to a depth of about one-half

10 the thickness of the shape memory film.